

# From Quality to Innovation: Evidence from two French Employer Surveys\*

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*Conference "Organizing for Internal and External Knowledge Creation and Innovation:  
Looking Within or Searching Beyond?"  
Copenhagen Business School - CBS  
October, 30th and 31st 2008.*

## **Abstract.**

In this article we investigate the impact of quality systems on innovation performance using the method of selective matching. We use two French microeconomic surveys, the "Organizational Changes and Computerization" (COI 1997) and the "Community Innovation Survey" (CIS3 1998-2000). In our first hypothesis we highlight the positive impact of quality (ISO 9000 certification) on certain areas of innovation performance, and we explain the contradiction in the literature about their relationship. Furthermore, the second hypothesis indicates that the innovation performance of firms with Top Quality Level is higher than that of Medium Quality Level which is also higher than Low Quality Level firms for certain innovation areas. However, we found that the difference in innovation performance between firms with Medium and Low quality levels is not of a great magnitude. This study implies that in order to achieve a significant innovation performance improvement, a well-established quality system is needed within the firm.

**JEL Code.** L15, O31, Q55

**Key-words.** Quality, Innovation, ISO certification, Selective Matching

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\* We are grateful to M.-A. Diaye, Nathalie Greenan and participants of the 1st DIME Scientific Conference on "Knowledge in space and time: economic and policy implications of the Knowledge-based economy", CIS4 French user Group, ZEW Summer Workshop on Economics and Econometrics of Innovation, 5<sup>èmes</sup> Doctoriales du GDR TIC et Société and Conference "Knowledge for Growth: European Strategies in the Global Economy" for their helpful comments and suggestions. The usual disclaimer applies.

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*“The introduction of new goods (...), new methods of production (...),  
the opening of new markets (...), the conquest of new sources of supply (...)  
and the carrying out of a new organization of any industry”*

(Joseph Schumpeter, 1934)

## **1. INTRODUCTION**

The developments in technology over the last ten years have changed the characteristics of business drastically. A great increase in market competition has accelerated the globalisation of international companies and changed business requirements. Many firms have responded to these changes by using quality-based strategies (Foley et al., 1997) that can drive firms to make significant improvements in profitability, productivity and competitiveness (Deming, 1986). In parallel to becoming quality-oriented, firms have also been urged to become more innovative (Encaoua et al., 2000; Kleinknecht and Mohnen, 2001). In many firms barriers to innovation are difficult to overcome without implementing quality practices. In that sense, quality in its human and technical dimensions can help create an environment and culture that supports innovation. More precisely, quality dimensions such as customer focus, employee training and team work can facilitate innovation improvement. Furthermore, there are many common aspects to quality practices and innovation performance (Prajogo and Sohal, 2001). This relationship between quality and innovation highlights that the objectives of innovation should conform to the objectives of quality.

The literature presents conflicting arguments concerning the impact of quality on innovation (Kanter, 1983; Flynn, 1994; Glynn, 1996; Roffe, 1999; Prajogo and Sohal, 2004; Abrunhosa and Moura E Sà, 2008). One set of arguments supports a positive relationship between quality and innovation, implying that firms implementing quality also improve their innovation performance. The opposite set of arguments claims that quality will hinder firms from being innovative due to several inherent factors that are not congruent with the aim of innovation. From this literature, we can summarize that the

impact of quality on innovation depends both on the specific quality system under consideration and the type of innovation. Up to date, studies have usually been focused either on the Total Quality Management system (TQM) or quality in general at the firm level, while only few studies have investigate ISO 9000 certification as a quality reference. In fact, to the best of our knowledge no study has previously investigated the wide network of relationships between the firm and its external environment when studying the quality-innovation relationship. Furthermore, various dimensions of innovation can be distinguished (product, process, incremental, radical, technological, non-technological), however, many studies did not specify which dimensions of innovation they had considered when analysing the impact of quality (Singh and Smith, 2004).

The central question of this paper is whether quality has a positive effect on innovation. Moreover, this research contributes to an improved understanding of the quality–innovation relationship in four ways. Firstly, we have used a unique French database that has permitted us to investigate quality and innovation performance in great detail. Secondly, in contrast to previous research, this paper presents three different Quality Levels, based on either ISO 9000 certification or additional systems to ISO 9000 and also deals with networks of relationships between the firm and its external environment. Thirdly, the paper distinguishes between nine indicators of innovation performance. Finally, we have corrected for bias selection using the matching method.

This paper has used two French microeconomic surveys called the “Organizational Changes and Computerization<sup>3</sup>” (COI 1997) and the “Community Innovation Survey<sup>4</sup>” (CIS3 1998-2000), which contain a sample of 1 146 manufacturing firms with at least 20 employees including detailed information on background characteristics, quality practices and innovation performance.

The design of the paper is as follows. Section 2 reviews the literature on the ISO 9000 certification, innovation performance and the impact of quality on innovation. In Section 3, we develop the data, the

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<sup>3</sup> Changement Organisationnel et Informatisation (COI), 1997, [www.enquetecoi.net](http://www.enquetecoi.net).

<sup>4</sup> Enquête Communautaire sur l’Innovation (CIS3), 2000, <http://www.industrie.gouv.fr/sessi/enquetes/innov/cis3/innov1.htm>

hypothesis, the econometric methods used and the main results. Section 4 is devoted to conclusive remarks.

## **2. LITERATURE REVIEW**

### ***2.1. ISO 9000 certification and innovation performance: definitions and key principles***

Before discussing the literature on the impact of quality on innovation, we define quality and innovation. In our study, we focus on ISO 9000 certification as a core Quality Level structure.

ISO 9000 standards were created to facilitate a mutual understanding of quality management system requirements in national and international trade. The notion that ISO 9000 is a generic standard implies that the same standards can be applied to any organization, regardless of company size, product line, and economic sector. Companies that adopt the ISO 9000 standard can be assured that their quality programs are built on a firm foundation of state-of-the art quality practices (ISO, 2004). They are not focused on the product/service quality, but on the related processes, enlarging their reach into the entire network of interactions in which the firm is participating.

Implementation of the ISO 9000 standard presents an organisational, strategically influenced change process which concerns the whole organisation and involves changes in the fundamental behaviour and applied routine of employees. Internally, stated benefits of ISO certification are that it has a positive influence on the employees of a firm in different respects i.e. significant improvements in employee involvement, personnel qualifications and multi-skilling, improved leadership, better access to tools, regular meetings, better knowledge, improved awareness of problems among employees, and a better team spirit.

The review of the literature indicates that ISO 9000 certification can deliver business advantages in general for the firm. Douglas et al. (2003) contend that ISO 9000 certification leads to quality improvement. Anderson et al. (1999) find that exports to Europe and elsewhere increase U.S. firms' likelihood of seeking ISO 9000. Terlaak and King (2006) find sales growth that is consistent with signalling models contributing to the adoption of ISO 9000. Naveh and Marcus (2004) find that going beyond the requirements of the quality standard increases value to the firm in the United States. Terziovski et al. (2003) find that ISO 9000 certification has a positive effect on business performance. Corbett et al. (2005) suggest that ISO 9000 certification leads to an important improvement in financial performance. Diaye et al. (2008) indicate that ISO 9000 certification improves the economic performance of the firm.

Despite these success stories, however, there are residual disadvantages of ISO 9000 certification. Some criticize the implementation of ISO 9000 as costly and time-consuming, which has also discouraged particularly small companies.

The literature review defined innovation as “implementing new ideas that create value” which refers to the various types of innovation such as product development, the deployment of new process technologies, and management practices (OECD, 1996). Many studies have been devoted to the determinants of innovation and research and development (R&D). The most frequently examined factors are size and type of the firm, industrial sectors, group membership, technological opportunities, market share, information source, degree of competition and the capacity for appropriation of the innovation benefit (Crépon et al., 1998; Encaoua et al., 2000; Kleinknecht and Mohnen, 2001). Then, the literature distinguishes three dimensions enhancing innovation, such as: factor conditions (human resources, basic research infrastructure, information infrastructure, and the supply of capital risk), supporting environment (competition, innovation incentives, presence of clusters, and local suppliers) and demand conditions (sophisticated customers, anticipated needs). However, an approach which empirically studies the relationship between quality management system and different innovation indicators has been marginalized.

## ***2.2. The impact of quality systems on innovation performance***

A review of the literature suggests that there are conflicting arguments concerning the impact of quality systems on innovation performance. The arguments for a positive impact of quality on innovation performance could be based on the similarities of the determinants of both quality and innovation, especially the internal determinants (for a review of the literature see Perdomo-Ortiz et al., 2006). Perdomo-Ortiz et al., (2006) conclude that although all the dimensions of TQM are related to business innovation capability (BIC), three of them stand out: process management, product design and human resource management. Claims that support a positive relationship between quality management and innovation suggest that companies embracing quality in their system and culture will provide a fertile environment for innovation because quality embodies principles that are congruent with innovation (Mahesh, 1993; Roffe, 1999). As Zairi (1994) remarked, TQM has “given organisations the impetus and commitment required for establishing climates of never-ending innovation or innovativeness”. Prajogo and Sohal (2004) analysed the effects of TQM on product innovation concluding that two dimensions of TQM, leadership and people management, have a significant influence in this domain. Santos-Vijande and Alvarez-Gonzalez’s (2007) empirical findings confirm that TQM strongly influences technical and administrative innovation regardless of the market turbulence in which the firm operates. The authors argue that the implementation of TQM through its dimension of people management is actively involved in offering the employees a real role in the management of the organization which may influence the firm's basic beliefs and values related to the innovation performance. Furthermore, Hoang et al. (2006) conclude that TQM practices, in general, support the firm’s innovation performance. Their findings indicate that TQM significantly and positively impacts the level of newness and especially the number of new products and services commercialized. The author’s results show that three constructs, leadership and people management (including top management commitment, employee involvement, and employee empowerment), process and strategic management (including process management, information and analysis system and strategic management), and open organization have a positive impact on the innovation performance of the companies surveyed in Vietnam. However, findings suggest that education and

training, while showing a positive effect on the number of new products and services, had a negative relationship with the level of newness. Moreover, authors did not find any evidence for the impact of customer focus (as an important TQM prospective) on the firm's product and service innovation performance. Similarly, a study by Abrunhosa and Moura E Sà (2008) on Portuguese footwear firms finds that TQM principles such as communication, supportive people management practices and teamwork have a positive association with the adoption of technological innovation. On the other hand, they conclude that not all TQM principles will improve innovation performance (autonomy and consultation). In the same sense, Benner and Tushman (2002) suggest that as process management practices reduce variance in organizational routines, they influence the selection of innovations. In the paint and photography industry, they find that the extent of process management activities in a firm are associated with an increase in both exploitative innovations that build on existing knowledge and an increase in exploitative innovations' share of total innovations.

In contrast to the above arguments, several authors reject the positive impact of quality management systems on innovation for the reason that they possess principles that could hinder innovation. While standardization is necessary for conformance and error reduction, it could result in rigidity from the innovation point of view (Kanter, 1983; Glynn, 1996). Moreover, standardization could drive a reduction in ambiguity in the design of tasks, which makes innovation difficult. Furthermore, it leads to lower flexibility and openness to change as a result of the "adhesion" that is generated to the repeated behaviour (Prajogo and Sohal, 2004). The problem solving method taught by TQM emphasizes the use of data, indeed one of the most famous terms used in TQM literature is "management by fact". This term strongly promotes the idea of rational thinking supported by a set of data, tools, and techniques. In this sense, Glynn (1996) suggests that in situations where a problem is familiar, prior experience may lead to the direct retrieval of the prior solution - as in the case of routinized problem solving. This means that if workers are allowed to deal only with routine operational problems, then it would be unlikely that they would produce innovative solutions. Furthermore, Flynn (1994) argues that rapid product innovation and quality improvement cannot be simultaneously achieved. This implies that in certain situations (when industry and market conditions

are taken into consideration) firms have to prioritize quality over innovation or vice versa. Moreover, results presented by Singh and Smith (2004) indicate that there is insufficient statistical evidence to suggest that TQM is related to innovation. The authors underline that the model presented in this study reflects a rather simplistic linear relationship between TQM constructs and innovation. They conclude that TQM constructs and innovation are related in a more complex way.

We presume that as innovation is a result of a combination of different activities, such as research and development, process development, design, marketing, organizational restructuring, resource management and employee development, it is likely to be supported by quality systems such as ISO 9000 that enhance the possibilities for such combination.

### **3. EMPIRICAL ANALYSIS**

#### ***3.1. The database***

This research is based on two cross-sectional French surveys, the “Organizational Changes and Computerization” (Changement Organisationnel et Informatisation COI 1997) and the “Community Innovation Survey” (Enquête Communautaire sur l’innovation CIS3 1998-2000).

The COI survey is a matched employer / employee survey on organizational change and computerization. This survey was created by researchers and statisticians from INSEE (National Institute for Statistics and Economic Studies), DARES (Ministry of Labor) and CEE (Center for Labor Studies). This collaboration gathered together a great deal of knowledge and expertise, which has made it possible to put together surveys of different firms and survey concerning employees section (labour force). In this survey, we can find the manufacturing industry, the agro-food industry, branches of the services industry (i.e. accountancy), and branches of the commercial industry. This survey describes work organizational practices in 1997 and changes that have occurred since 1994. Firms were interviewed on the economic goals of organizational change and the economic context in which

those decisions were made. This COI survey has been used recently by several researchers like Acemoglu et al. (2007) and special issue of *Revue Economique*.

The CIS3 survey, carried out by SESSI (Ministry of Economics, Finances and Industry) over the period 1998-2000, is based on the Oslo Manual drawn up by the OECD, and revised in 1996. Manufacturing firms, with at least 20 employees, answer questions primarily concerned with the nature of technological innovations, innovation performance, the supervision of these innovations (i.e. innovation projects), the internal and external sources of R&D, the objectives of technological innovation, the principal sources of information, the cooperation to innovate and finally the obstacles to innovation projects. CIS data have been used in over 60 recent academic articles, mainly in economics (for prominent contributions using CIS data see Mairesse and Mohnen, 2002).

Merging these two surveys we get a unique database which provides detailed information on firms' characteristics, quality systems and innovation performance. It is important to mention that these two surveys are mandatory for all firms. The merger of these data sets provides a sample of 1 146 manufacturing firms. Appendix A provides variables' definitions.

### ***3.2. Measuring quality and innovation***

As we said above, we use ISO 9000 certification as a quality reference. A new feature of this paper is that three original measures of Quality Level are created. The relationship between firms and their substitute or additional system to ISO 9000 will determine the Quality Level established inside the firm. The focus on openness and interaction in studies of innovation suggests that the network of relationships between the firm and its external environment can play an important role in performance evaluation. The study by Helper and Kiehl (2004) indicates that two-thirds of suppliers respond to their customers' demands for improved quality, cost, and delivery by adopting policies such as total quality management. So, dealing with a quality certified supplier while non-certified improves your signals concerning quality improvement (Diaye et al., 2008).

The first category of firms is called firms with Top Quality Level and it includes firms that have ISO 9000 certification, where suppliers are also certified or have other systems of certification or total quality. Furthermore in this group we include firms that are ISO certified and also have other systems of certification or total quality. The third possibility for the group of Top Quality Level is that firms are certified and their suppliers are also certified, but they do not have another system of certification or total quality. This group presents the highest Quality Level on the hierarchy. We consider that being a Top quality firm demands at least ISO certification and an other type of quality support (certified suppliers and/or other type of system of certification).

The second category is called Medium Quality Level and it includes firms that are not ISO certified but which have another system of certification or total quality and their suppliers have ISO certification. In this category we include also firms that have only either ISO certification or another system of certification or total quality or whose suppliers are ISO certified. Being a Medium Quality Level firm implies at least one linkage, internal or external, to quality system.

The third category named Low Quality Level includes firms that are not ISO certified, do not have any other system of certification or total quality and whose suppliers also do not have ISO certification. Having no internal or external linkage to a quality system induces the status of a Low Quality Level firm.

This categorisation allows us to empirically construct the different levels of quality to understand their effect on the improvement of innovation performance.

Innovation performance is conceptualized by three aspects: product innovation, process innovation and innovation activities. We use nine indicators of innovation performance: five dichotomous indicators of innovation, and four continuous indicators which are provided by the third Community Innovation Survey. Product innovation presents the introduction of a new product (service) on the

market or the significant improvement of one product (service) that will meet customer demand. Under this category we will analyze four variables: a new or improved product for the firm, turnover due to new or improved products, new or improved products on the market and share of new or improved products to the market. The approach called process innovation combines the adoption of a process view of the business with the application of innovation to key processes. We distinguish three types of processes innovation that represent our dependent variables: process innovation in general, technologically new processes and new process (non-technological). Furthermore, the third category of innovation area (called innovation activities) includes two variables: total innovation expenditure and number of innovation projects.

### ***3.3. Hypothesis and Propensity Score Estimates-estimation strategy***

In this paper we aim to study the positive effects of quality systems on innovation performance. Following the above we formulate the following hypothesis:

*H1: Firms with ISO 9000 certification will improve their innovation performance.*

Furthermore, we want to verify the claim that improvement of innovation performance varies according to the Quality Level that already exists inside the firm. We want to provide an empirical answer to the question of whether the position inside the quality hierarchy is positively correlated with innovation performance. Consequently, we formulate the following hypothesis:

*H2: Different levels of quality differentially improve innovation performance.*

However the position in the quality hierarchy may not be random and may depend on the firms' individual characteristics: results may be subject to a selection bias. To address this, we use a propensity score matching method. An ideal measurement of the effect of quality on innovation

performance would be derived by comparing for each firm  $i$ , the  $INNO_{i1}$  value of the relevant innovation indicators, product innovation, process innovation or innovation activities, in the event of quality ( $T_i = 1$ ) to a  $INNO_{i0}$  value taken in the absence of quality ( $T_i = 0$ ). However, in practice, only the results of the current quality situation are observable for each firm and innovation outcomes that would have resulted from a different quality strategy need to be estimated. This is precisely what selective matching methods are intended to do.

Following Rubin (1974), the difference between the impact of a firm with quality systems and what the impact would be if a firm did not have quality systems is noted  $C = INNO_1 - INNO_0$ . The individual treatment effect is unobservable, and consequently its distribution is not identifiable. If the property of independence is respected ( $INNO_0, INNO_1 \perp T$ ), there would be no selection bias. Thus three quantities are of interest to us:  $C = E[INNO_1 - INNO_0]$  is the average treatment effect over the whole population,  $C_1 = E[INNO_1 - INNO_0 | T = 1]$  is the average treatment effect over treated firms and  $C_0 = E[INNO_1 - INNO_0 | T = 0]$  is the average treatment effect over non-treated firms. For each dependent variable, we will estimate the quantities  $C$ ,  $C_1$  and  $C_0$ .

This procedure was extensively studied by Heckman and his co-authors in a series of papers where the matching principle is extended through kernel or nearest neighbour techniques to provide a non parametric estimate of the treatment effect given the value of the propensity score (Heckman et al., 1997, 1998). We will use a non parametric Kernel matching. Moreover, in order to estimate the treatment effect of quality inside the firm, we have to construct for each treated firm a counterfactual from firms in the non treated population. The innovation outcome of this counterfactual firm is a weighted average of the outcome of the comparison group members. More precisely, for a given firm, the weighting coefficients used to construct the counterfactual firm depend on the distance between the firm's score and the score of each firm of the comparison group.

The results of Rosenbaum and Rubin (1983) help in constructing a group of untreated firms. Using such a constructed group we may be able to say something about the effect of quality on innovation performance. The untreated group could be for instance composed of firms that are similar to the treated firm, with respect to background characteristics such as size, industry, features of firm's strategy and external constraints. In other words a counterfactual can only be constructed for the firms whose propensity score belongs to the intersection between the support of the propensity score distribution of the treated firms and the support of the propensity score distribution of the non treated firms. Consequently an important point in the estimation concerns the determination of the common support of the propensity score distributions defined by the intersection of the probabilities intervals of the treated and of the non-treated firms (defined by their first and 99<sup>th</sup> percentiles).

For selecting comparable firms, we have to estimate a Logit model of being ISO 9000 certified (*H1*) and derive the corresponding propensity score (PS). We also estimate three Logit models of choosing one Quality Level among Top, Medium or Low (*H2*). Following Bonjour et al. (2001) and Lechner (2001) we will use three binomial models rather than a multinomial model. As Lechner (2001) indicates, there is little difference in their relative performance but he suggests that the binomial models present marginally more accurate results.

### ***3.4. Descriptive Statistics***

Tables 1 and 2 provide descriptive statistics for ISO 9000 certification and three Quality Levels. From Table 1, we can notice that six firms out of ten are ISO 9000 certified. Furthermore, the construction of three Quality Levels is presented in the same table. The distribution of each category of Quality levels is: 61%, 22%, and 17% for the Top Quality Levels firms, Medium Quality Levels firms and Low Quality Levels firms respectively.

**[INSERT Table 1.]**

**[INSERT Table 2.]**

Table 2 provides the ISO 9000 certified and three Quality Levels firms' descriptive statistics according to their background characteristics such as size, features of firm's strategy and external constraints.

The widest dispersal of ISO 9000 certified or Top Quality Level firms is within firms with 200 employees and more. We can assume that firm size positively influences its propensity to become ISO 9000 certified or among one of the three types of Quality Levels. Cost reduction is an important feature since nine firms out of ten consider this strategy as important or very important. However, half of the firms in each category do not suggest that new procedures are important or very important features of their strategy. In contrast firms in each category estimate competitive pressure and clients conditions as important external market constraints. Moreover, approximately 60% of firms find that uncertainty on the market influenced their engagement in quality. 37% of ISO 9000 certified and Top Quality firms find that stockholder conditions present important market constraints. 28% of Medium Quality Level firms and 15% of Low Quality Level firms are influenced by stockholder conditions concerning their quality orientation. Finally, approximately only 20% of firms in each category consider suppliers' conditions as an important constraint.

### ***3.5. Determinants of the ISO adoption and Quality Levels***

As explained above, the first part of PS-estimates is defining the determinants of being ISO certified (*H1*) or belonging to one of the Quality Levels (*H2*) using background characteristics such as size, sector of activity, features of firm's strategy and external constraints (Table 3).

The first group of variables that we have used includes firm's size and sector of activity. We found the same results as in the literature relating to the adoption of ISO certification (Anderson et al., 1999; Terlaak and King, 2006). Generally, the firm's size mainly determines its chances, in the sense of financial resources, to become ISO certified or to operate at a superior Quality Level. We can note that company size is positive and significant for the four logistic regressions. We have used eleven sectors of activities and we define as a reference the sector of textile and mineral industries. As in the literature, we find that the probability of being ISO certified is stronger in some industries, like the electrical and electronic equipment, metal, construction and mechanical equipment industries. Similar results are obtained for our three Quality Level categories which highlights that certain sectors of activity tend to be more sensitive to quality systems than others.

Concerning the features of the company's strategy, we can see from Table 3 that for our four logistic regressions, the coefficients associated to cost reduction and implementation of a new production procedure when they are significant, are positive. In other words, when cost reduction and new procedures are important or very important for the company's strategy, they will increase the company's probability of being quality certified. When comparing Medium Quality Level firms to Low Quality Level firms, there is no variable that plays such a part in the decision to belong to Medium Quality Level firms.

Considering the five external market constraints, one can remark that for all four estimated regressions, the variables of competitive pressure, uncertainty on the market and suppliers-conditions seem to play no role in determining the firm's probability to be ISO certified or to be in one Quality Level. Clients' conditions have an important positive impact on choosing between Top and Low Quality Level firms and between Medium and Low Quality Level firms. When we look at the variable stockholders-conditions the associated coefficients, when significant, are positive. This tells us that when stockholders' conditions are an important external constraint, firms will adopt quality systems. Surprisingly, all five external market constraints have no influence to ensure a firm operates at Top rather than Medium Quality Level.

[INSERT Table 3.]

### ***3.6. Discussion of the PS- matching results***

We will first introduce the PS-matching results and then compare these results with the naïve ones, revealing some selection effects.

The findings provide empirical evidence (Table 4) that ISO 9000 certification significantly and positively contributes to seven out of nine indicators of innovation performance. More precisely, correlation between ISO 9000 and innovation is positive and significant concerning products (New or improved products for the firm, Turnover due to new or improved products, New or improved products on the market and Share of new or improved products to the market), processes (Technologically new process) and innovation activities (Total innovation expenditure and Number of innovation projects). Moreover, it is in its precise form that ISO 9000 certification seems to be positively associated with innovation performance. Therefore, the hypothesis that the firms that adopt ISO 9000 certification will improve their innovation performance (*HI*) is supported for certain innovation indicators.

Furthermore, the comparison of the results of the naïve estimates (Table 4, last column) with the results of the PS-matching provides evidence that results are different. Indeed in general, the figures of the naïve estimates are different (and higher) than those of the PS-matching results revealing some selection effects. For example, the mean difference in terms of new or improved products for the firm between ISO Adopters and Non Adopters is 0.27 (significant at 1%) while this difference is only 0.12 (significant at 1%) for PS estimator.

It can be seen from Tables 5a, 5b and 5c that the likelihood of being innovators can be ranked as follows: Top Quality Level firms, Medium Quality Level firms and Low Quality Level firms. More

precisely, the results indicate that Top Quality Level firms are more innovative than those of Medium than those of Low Quality Level.

From the Table 5a, we can conclude that Top Quality Level firms have a positive impact on product innovation (New or improved products for the firm, Turnover due to new or improved products, New or improved products on the market and Share of new or improved products to the market), process innovation (New or improved processes and Technologically new process) and innovation activities (Total innovation expenditure). Therefore, Top Quality Level firms impact positively seven out of nine indicators of innovation performance. Furthermore, we can conclude that Top and Medium Quality Level firms act similarly on the number of innovation projects. More precisely, those two types of firms have a very similar impact on this part of innovation performance.

From Table 5b, findings suggest that there is no difference in impact between Top and Low Quality Level firms on Turnover due to new or improved products and all three categories of innovation process. However, Top Quality Level firms improve significantly and positively in five out of nine innovation performance indicators. More precisely, they have an impact on product innovation (New or improved products for the firm, New or improved products on the market and Share of new or improved products to the market) and innovation activities (Total innovation expenditure and Number of innovation projects).

The last Table 5c provides the conclusion that there is some difference between the effects on the innovation of firms when comparing Medium and Low Quality Level. Firms with a Medium Quality Level see a positive impact on four out of nine areas of innovation, product innovation (New or improved products of the firm and New or improved products on the market) and innovation activities (Total innovation expenditure and Number of innovation projects). Furthermore, we can conclude that even though Medium Quality Level firms do not have well established quality system, the quality signals that they receive via additional or substitute certification or indirect (via suppliers) could

enhance innovation performance. These results confirm that substitution or external linkages with firms with well-established quality systems can help to improve innovation performance.

Therefore, the evidence generally supports hypothesis *H2* stating that different levels of quality have a differentiated impact on innovation performance.

From the findings above we can conclude that alternative quality systems improve innovation performance in a manner similar to the improvements seen with the ISO 9000 standard,. The positive impact of quality systems on product innovation could be explained by the principle of customer satisfaction. It is well known that quality oriented firms focus on customer satisfaction, which implies obtaining information about both current and future customer needs, and taking into account the full range of environmental forces that will help the development of new products (Santos-Vijande and Alvarez-Gonzalez, 2007). Furthermore, significant improvements brought about by the ISO 9000 standard, in employee involvement, improved leadership, better access to tools, regular meetings and a better team spirit will result in a greater sense of autonomy, responsibility and creativity which will enhance innovation.

However our results also demonstrated that certain innovation indicators (New process (non-technological)) cannot be improved by quality standard. Similar results are obtained by Santos-Vijande and Alvarez-Gonzalez (2007), who did not find any direct effect of TQM on technical innovation. We can conclude that technical innovations require a different model of practices or a different organisational structure under the ISO 9000 standard. In other words, quality systems have to be integrated with other organisational resources to influence greater technological innovation.

**[INSERT Table 4.]**

**[INSERT Table 5a.]**

[INSERT Table 5b.]

[INSERT Table 5c.]

### *3.7. Assessing the Matching Quality*

To ensure the effectiveness of our model we checked if the matching procedure balanced the distribution of the relevant variables in both the control and treatment group. We used the Standardised Bias approach to determine this.

The Standardised Bias approach assesses the distance in marginal distribution of the X-variables (Rosenbaum and Rubin, 1985). For each covariate X it is defined as the difference of sample means in the treated and matched control subsamples as a percentage of the square root of the average of sample variances in both groups. Moreover, this type of test indicates how much each matching variable in model reduces bias selection. In the model ISO certified firms vs. non ISO certified firms the lowest bias reduction is around 15%, going up to 70% for the highest one. Concerning Top vs. Medium Quality Level firms the reduction of selection bias varies from 5% to 65%. The third model, Top vs. Low Quality Level firms, reduces bias till 93%. The last model, Medium vs. Low Quality Levels firms, the bias reduction goes from 6% till 46%.

#### **4. CONCLUSION**

This paper provides empirical findings that support the notion that quality practices improve innovation performance. This approach is based on the argument that quality practices, in both their human and technological dimensions, help to create an environment and culture that support innovation. Moreover, quality systems allow for better customer orientation, employee involvement, improved leadership, better access to tools, regular meetings and better team spirit, all of which will improve innovation performance.

Our work adds to the growing body of literature concerning the impact of quality on innovation performance in four unique ways. Firstly, we have used a unique French database that provides information on firms' characteristics, quality systems and innovation performance. Secondly, we have used three different Quality Levels, based on either ISO certification or additional certification and considered the network of relationships between the firm and its external environment. Thirdly, we have analysed different innovation areas using nine innovation indicators. Finally, using propensity score methodology we have corrected for bias selection.

Our empirical evidence is consistent with the first hypothesis stating that there is a positive and significant relationship between ISO 9000 certification and innovation performance. However, it seems that there are certain fields of innovation where a quality system has no significant effect. Moreover, our results suggest that the impact of quality systems on innovation varies according to the type of innovation examined. This suggests that in order for quality systems to achieve maximum impact across the full range of innovation practices they have to be integrated with other organisational resources existing within the firm.

Concerning the second hypothesis, our findings demonstrate that there is a positive and significant relationship between Quality Levels and innovation performance for certain areas of innovation. This is particularly true when we compare and contrast Top and Medium Quality Level, and Top and Low Quality Level. Furthermore, four innovation indicators can be positively influenced by Medium

Quality Level firms as compared to the impact obtained by Low Quality Level firms. This indicates that firms can utilise additional or substitute certification or even access indirect certification (via suppliers) in order to make a positive impact on certain innovation areas. Importantly, in terms of business implications, these results imply that Medium Quality Level firms can still make a positive impact on innovation whilst avoiding costly processes of ISO 9000 certification. In other words, by switching to only one position up on the quality hierarchy, (i.e. becoming Medium Quality Level), firms can improve their innovation performance. However, those firms that want to pursue a high level of innovation performance must have the capability to fully manage quality requirements. In conclusion, an established quality management system is a prerequisite for excellent innovation performance, and a substitute or indirect certification (through suppliers) is not sufficient for significant innovation performance improvement.

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**Table 1. Distribution of ISO 9000 certification and three categories of Quality Levels**

Type of Quality Level	ISO 9000 certified firms	ISO 9000 certified suppliers	Other system of certification or total quality	Total
Top Quality Level	yes	yes	yes	61%
	yes	no	yes	
	yes	yes	no	
Medium Quality Level	yes	no	no	22%
	no	yes	yes	
	no	yes	no	
Low Quality Level	no	no	yes	17%
	no	no	no	
	no	no	no	
<b>Total</b>	<b>64%</b>	<b>76%</b>	<b>45%</b>	

Source: Survey COI merges to the CIS3, sample 1146 companies, not weighted by the number of employees.  
Field: manufacturing industries of more than 20 employees.

**Table 2. Descriptive Statistics**

	ISO 9000 certification	Top Quality Level	Medium Quality Level	Low Quality Level
<b>Company's Size</b>				
20 to 199 employees	22% (a)	21%	43%	68%
200 employees and more	78%	79%	57%	32%
<b>Features of the company's strategy</b>				
Cost reduction	94%	95%	87%	80%
New procedure	56%	57%	48%	43%
<b>External market's constraints</b>				
Competitive pressure-yes	81%	82%	76%	69%
Uncertainty on the market-yes	59%	59%	61%	54%
Clients conditioned- yes	78%	79%	74%	65%
Suppliers conditioned-yes	16%	17%	19%	21%
Stockholders conditioned-yes	37%	37%	28%	15%
<b>Total</b>	732 64%	705 61%	247 22%	194 17%

Source: Survey COI merges to the CIS3, sample 1 146 companies, not weighted by the number of employees.  
Field: manufacturing industries of more than 20 employees.  
Lecture: (a) 22% of firms certified with ISO 9000 have from 20 to 199 employees (category-small company).

**Table 3. Determinants of choosing the ISO 9000 certification and Quality Levels**

	(H1) ISO Certified Firms vs ISO Non Certified firms (ref)	(H2) Top Quality Level vs Medium Quality Level (ref)	(H2) Top Quality Level vs Low Quality Level (ref)	(H2) Medium Quality Level vs Low Quality Level (ref)
<b>Intercept</b>	-1.96***	-1.10**	-2.99***	-1.49***
	<b>Size of the company</b> <i>Ref = 20 to 199 employees</i>			
<b>200 employees and more</b>	1.56***	1.09***	2.50***	1.28***
	<b>Features of the company's strategy</b> <i>Ref = Less Important and Not Important</i>			
<b>Cost reduction</b>	0.49**	0.48	0.55	0.36
<b>New procedure</b>	0.25	0.27*	0.58**	0.03
	<b>External market's constraints</b>			
<b>Competitive pressure-yes</b>	0.07	0.11	0.22	0.20
<b>Uncertainty on the market-yes</b>	-0.00	-0.03	0.39	0.07
<b>Clients conditioned- yes</b>	0.15	-0.03	0.75**	0.47*
<b>Suppliers conditioned-yes</b>	-0.13	-0.06	-0.21	-0.14
<b>Stockholders conditioned-yes</b>	0.40**	0.26	0.68**	0.38
	<b>Sector of Activity</b> <i>Ref = textile and mineral industries</i>			
<b>Industry of leather and wearing</b>	-1.91***	-1.14*	-2.69***	-1.29**
<b>Industry of edition, printing and reproduction</b>	-1.87***	-0.99*	-2.80***	-1.24**
<b>Pharmaceutical industry, manufacture of soap, perfumes and care products</b>	-0.45	-0.76**	1.05*	1.38***
<b>Industry of home equipment</b>	-0.06	-0.12	0.28	0.18
<b>Car Industry</b>	1.82***	1.75***	2.11***	0.59
<b>Naval construction , railroad materials/ Manufacture of electric and electronic equipment</b>	-1.52***	1.16***	2.90***	1.26**
<b>Manufacture of mechanical equipment</b>	1.31***	1.01***	1.98***	1.11***
<b>Manufacture of paper and wood/ chemistry, rubber and plastic</b>	1.14***	0.93***	1.68***	0.67**
<b>Manufacture of metal transformation/ Manufacture of electric components</b>	2.09***	1.69***	2.99***	1.47***
<b>Manufacture of carburant/ Electricity, gas and water supply</b>	0.82**	0.98**	1.44**	0.23
<b>Max-rescaled R-Square</b>	0.40	0.23	0.60	0.31
<b>Number of firms</b>	1 146	952	899	441

Source: Survey COI merges to the CIS3.

Field: manufacturing industries of more than 20 employees.

Notes: (\*), (\*\*) and (\*\*\*) indicate parameter significance at the 10, 5 and 1 percent level respectively.

**Table 4. PS-matching estimates – ISO 9000 Impacts on Innovation Performance (H1) (a)**

	Global	Treated	Non-treated	Difference of Mean (b)
	<b>Effect on Product (ISO Certified Firms vs ISO Non Certified Firms)</b>			
<b>New or improved products for the firm</b>	0.13***	0.12***	0.12***	0.27***
<b>Turnover due to new or improved products</b>	0.03***	0.03***	0.02**	0.05***
<b>New or improved products on the market</b>	0.12***	0.13***	0.10**	0.21
<b>Share of new or improved products to the market</b>	0.03***	0.02**	0.03**	0.03
	<b>Effect on Processes (ISO Certified Firms vs ISO Non Certified Firms)</b>			
<b>New or improved processes for the firm</b>	0.06	0.05	0.06	0.19***
<b>Technologically new process</b>	0.10**	0.10**	0.08**	0.15***
<b>New process (non-technological)</b>	-0.01	-0.02	-0.01	0.05***
	<b>Effect on Innovation Activities (ISO Certified Firms vs ISO Non Certified Firms)</b>			
<b>Total innovation expenditure (Logarithm)</b>	0.27**	0.31**	0.21*	0.39***
<b>Number of innovation projects</b>	0.09**	0.09*	0.10**	0.25***

Bootstrapped standard errors

Source: Survey COI merges to the CIS3, sample 1 146 companies.

Field: manufacturing industries of more than 20 employees.

The regression integrates 11 indexes of industries that correspond to NAF 36 (reference: textile and mineral industries).

Notes: (\*), (\*\*) and (\*\*\*) indicate parameter significance at the 10, 5 and 1 percent level respectively.

(a) The supports are available in Appendix C.

(b) The supports are available in Appendix B.

**Table 5a. PS-matching estimates - The difference between****Top and Medium Quality Level impact on Innovation performance (H2) (a)**

	<b>Global</b>	<b>Treated</b>	<b>Non-treated</b>	<b>Difference of Mean (b)</b>
	<b>Effect on Product (Top Quality Level vs Medium Quality Level)</b>			
<b>New or improved products for the firm</b>	0.09**	0.09**	0.08*	0.17***
<b>Turnover due to new or improved products</b>	0.04***	0.04***	0.03**	0.04***
<b>New or improved products on the market</b>	0.08**	0.09**	0.07*	0.15***
<b>Share of new or improved products to the market</b>	0.03***	0.03***	0.03***	0.03***
	<b>Effect on Processes (Top Quality Level vs Medium Quality Level)</b>			
<b>New or improved processes for the firm</b>	0.08*	0.08*	0.09**	0.14***
<b>Technologically new process</b>	0.12**	0.11**	0.13***	0.21***
<b>New process (non-technological)</b>	-0.00	0.00	-0.00	0.04
	<b>Effect on Innovation Activities (Top Quality Level vs Medium Quality Level)</b>			
<b>Total innovation expenditure (Logarithm)</b>	0.23**	0.25**	0.20*	0.20*
<b>Number of innovation projects</b>	0.05	0.5	0.05	0.13***

Bootstrapped standard errors

Source: Survey COI merges to the CIS3, sample 952 companies.

Field: manufacturing industries of more than 20 employees.

The regression integrates 11 indexes of industries that correspond to NAF 36 (reference: textile and mineral industries).

Notes: (\*), (\*\*) and (\*\*\*) indicate parameter significance at the 10, 5 and 1 percent level respectively.

(a) The supports are available in Appendix C.

(b) The supports are available in Appendix B.

**Table 5b. PS-matching estimates - The difference between  
Top and Low Quality Level impact on Innovation performance (H2) (a)**

	Global	Treated	Non-treated	Difference of Mean (b)
	<b>Effect on Product (Top Quality Level vs Low Quality Level)</b>			
<b>New or improved products for the firm</b>	0.19***	0.19***	0.19***	0.41***
<b>Turnover due to new or improved products</b>	0.02	0.02	0.03	0.06**
<b>New or improved products on the market</b>	0.16**	0.17**	0.12**	0.31***
<b>Share of new or improved products to the market</b>	0.03**	0.03**	0.03**	0.04**
	<b>Effect on Processes (Top Quality Level vs Low Quality Level)</b>			
<b>New or improved processes for the firm</b>	0.09	0.11	0.05	0.24**
<b>Technologically new process</b>	0.06	0.08	0.04	0.24
<b>New process (non-technological)</b>	-0.02	-0.02	-0.03	0.09
	<b>Effect on Innovation Activities (Top Quality Level vs Low Quality Level)</b>			
<b>Total innovation expenditure (Logarithm)</b>	0.63***	0.70***	0.45**	0.65***
<b>Number of innovation projects</b>	0.15**	0.15**	0.15**	0.37***

Bootstrapped standard errors

Source: Survey COI merges to the CIS3, sample 899 companies.

Field: manufacturing industries of more than 20 employees.

The regression integrates 11 indexes of industries that correspond to NAF 36 (reference: textile and mineral industries).

Notes: (\*), (\*\*) and (\*\*\*) indicate parameter significance at the 10, 5 and 1 percent level respectively.

(a) The supports are available in Appendix C.

(b) The supports are available in Appendix B.

**Table 5c. PS-matching estimates - The difference between Medium and Low Quality Level impact on Innovation performance (H2) (a)**

	Global	Treated	Non-treated	Difference of Mean (b)
	<b>Effect on Product (Medium Quality Level vs Low Quality Level)</b>			
<b>New or improved products for the firm</b>	0.18***	0.19***	0.18***	0.24***
<b>Turnover due to new or improved products</b>	0.02	0.02	0.02	0.02**
<b>New or improved products on the market</b>	0.11**	0.10**	0.11**	0.16***
<b>Share of new or improved products to the market</b>	0.01	0.01	0.01	0.01**
	<b>Effect on process (Medium Quality Level vs Low Quality Level)</b>			
<b>New or improved processes for the firm</b>	0.02	0.02	0.02	0.10**
<b>Technologically new process</b>	-0.01	-0.02	-0.00	0.03
<b>New process (non-technological)</b>	-0.02	-0.01	-0.01	0.04
	<b>Effect on Innovation Activities (Medium Quality Level vs Low Quality Level)</b>			
<b>Total innovation expenditure (Logarithm)</b>	0.26**	0.31**	0.21*	0.45***
<b>Number of innovation projects</b>	0.16**	0.16**	0.15**	0.24***

Bootstrapped standard errors

Source: Survey COI merges to the CIS3, sample 441 companies.

Field: manufacturing industries of more than 20 employees.

The regression integrates 11 indexes of industries that correspond to NAF 36 (reference: textile and mineral industries).

Notes: (\*), (\*\*) and (\*\*\*) indicate parameter significance at the 10, 5 and 1 percent level respectively.

(a) The supports are available in Appendix C.

(b) The supports are available in Appendix B.

**Appendix A.**  
**Definition of variables (the COI 1997 and CIS3 data sets)**

<b>Variable</b>	<b>Definition</b>
ISO 9000 in 1994	1 if certified with ISO 9000 standard in 1994, otherwise 0.
ISO 9000 in 1997	1 if certified with ISO 9000 standard in 1997, otherwise 0.
ISO 9000 Suppliers	1 if suppliers certified with ISO 9000 standard, otherwise 0.
Other types of certification	1 if have other system of certification or measure of total quality, otherwise 0.
Cost reduction	1 if strategic importance strong or very strong, otherwise 0.
New procedure	1 if strategic importance strong or very strong, otherwise 0.
Competitive pressure	1 if influenced the choice of firm's organisation and computerisation, otherwise 0.
Uncertainty on the market	1 if influenced the choice of firm's organisation and computerisation, otherwise 0.
Clients conditioned	1 if influenced the choice of firm's organisation and computerisation, otherwise 0.
Suppliers conditioned	1 if influenced the choice of firm's organisation and computerisation, otherwise 0.
Stockholders conditioned	1 if influenced the choice of firm's organisation and computerisation, otherwise 0.
New or improved products for the firm	1 if during 1998-2000 firm introduced into the market any new or significantly improved products (goods or services) for the firm, otherwise 0.
Turnover due to new or improved products	Estimation how turnover in 2000 was distributed between new or significantly improved products (goods or services) introduced during the period 1998-2000.
New or improved products on the market	1 if during 1998-2000 firm introduced into the market any new or significantly improved products (goods or services) for the firm's market, otherwise 0.
Share of new or improved products to the market	Estimation of new or significantly improved products (goods or services) not only new for your enterprise, but also new for firm's market contribution in total turnover in 2000.
New or improved processes for the firm	1 if during 1998-2000 firm introduced into the market any new or significantly improved production processes including methods of supplying services and ways of delivering products, otherwise 0.
Technologically new process	1 if during 1998-2000 firm introduced any technologically new or modified (with combination of new technologies) production processes, otherwise 0.
New process (non-technological)	1 if during 1998-2000 firm introduced any new (or modified) production new process (non-technological), otherwise 0.
Total innovation expenditure	Total innovation expenditure in 2000.
Number of innovation projects	1 if number of studied or realised innovation projects per year is more than 1, otherwise 0.

**Appendix B.**  
**Mean of Innovation Performance**

	<b>ISO 9000 Certified Firms</b>	<b>ISO 9000 Non Certified Firms</b>	<b>Top Quality Level</b>	<b>Medium Quality Level</b>	<b>Low Quality Level</b>
<i>New or improved products for the firm</i>	0.68	0.41	0.69	0.52	0.28
<i>Turnover due to new or improved products</i>	0.11	0.06	0.11	0.07	0.05
<i>New or improved products on the market</i>	0.46	0.25	0.47	0.32	0.16
<i>Share of new or improved products to the market</i>	0.06	0.03	0.06	0.03	0.02
<i>New or improved processes for the firm</i>	0.49	0.30	0.49	0.35	0.25
<i>Technologically new process</i>	0.33	0.18	0.40	0.19	0.16
<i>New process (non-technological)</i>	0.17	0.12	0.18	0.14	0.09
<i>Total innovation expenditure</i>	0.89	0.50	0.90	0.70	0.25
<i>Number of innovation projects</i>	0.62	0.37	0.62	0.49	0.25

Source: Survey COI merges to the CIS3, sample 1 146 companies.  
Field: manufacturing industries of more than 20 employees.

**Appendix C.**  
**Supports of the PS-matching estimates**

***ISO Certified Firms vs ISO Non Certified Firms***

*Model- New or improved products for the firm:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=774; max=1 094; mean=944.05.

*Model- Turnover due to new or improved products:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=813; max=1 084; mean=950.50.

*Model- New or improved products on the market:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=767; max=1 088; mean=940.81.

*Model- Share of new or improved products to the market:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=821; max=1 129; mean=943.32.

*Model- New or improved processes for the firm:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=777; max=1 065; mean=947.83.

*Model- Technologically new process:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=817; max=1 113; mean=946.37.

*Model- New process (non-technological):* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=752; max=1 105; mean=942.35.

*Model- Logarithm of total innovation expenditure:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=788; max=1 096; mean= 958.67.

*Model- Number of innovation projects:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=814; max=1 083; mean=958.54.

***Top Quality Level vs Medium Quality Level***

*Model- New or improved products for the firm:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=857; max=1 104; mean=999.37.

*Model- Turnover due to new or improved products:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=832; max=1 106; mean=998.85.

*Model- New or improved products on the market:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=852; max=1 105; mean=994.84.

*Model- Share of new or improved products to the market:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=865; max=1 112; mean=996.65.

*Model- New or improved processes for the firm:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=776; max=1 117; mean=1 008.14.

*Model- Technologically new process:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=903; max=1 115; mean=1 017.57.

*Model- New process (non-technological):* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=871; max=1 097; mean=1 005.65.

*Model- Logarithm of total innovation expenditure:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=823; max=1 115; mean= 996.02.

*Model- Number of innovation projects:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=835; max=1 112; mean=1 002.49.

### ***Top Quality Level vs Low Quality Level***

*Model- New or improved products for the firm:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=442; max=987; mean=618.18.

*Model- Turnover due to new or improved products:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=456 max=842; mean=623.17.

*Model- New or improved products on the market:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=445; max=860; mean=622.61.

*Model- Share of new or improved products to the market:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=434; max=976; mean=617.67.

*Model- New or improved processes for the firm:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=462; max=993; mean=634.47.

*Model- Technologically new process:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=464; max=984; mean=632.95.

*Model- New process (non-technological):* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=578; max=1 011; mean=814.44.

*Model- Logarithm of total innovation expenditure:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=412; max=949; mean= 629.37.

*Model- Number of innovation projects:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=432; max=954; mean=620.81.

### ***Medium Quality Level vs Low Quality Level***

*Model- New or improved products for the firm:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=451; max=1 146; mean=898.27.

*Model- Turnover due to new or improved products:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=735; max=1 146; mean=896.93.

*Model- New or improved products on the market:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=735; max=1 146; mean=896.93.

*Model- Share of new or improved products to the market:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=396; max=1 146; mean=894.10.

*Model- New or improved processes for the firm:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=656; max=1 146; mean=893.60.

*Model- Technologically new process:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=523; max=1 146; mean=984.57.

*Model- New process (non-technological):* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=396; max=1 146; mean= 880.71.

*Model- Logarithm of total innovation expenditure:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=439; max=1 146; mean= 883.28.

*Model- Number of innovation projects:* The standard deviation of the treatment effect is computed using bootstrap with 150 simulations. The characteristics of support over 150 simulations are: min=455; max=1 146; mean=894.33.